APPENDIX C

MECHANICAL ENGINEERING DESIGN CRITERIA

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C.1 PURPOSE AND SCOPE

This appendix summarizes and supplements key mechanical design standards, methods, and other pertinent general design elements in the project. The design criteria are the general basis for design of project mechanical systems and components. Mechanical components include pumps, compressors, turbines, heat recovery steam generators, heat exchangers; condensers, cooling towers, and fire protection components.

C.2 DESIGN-RELATED LAWS, REGULATIONS, CODES, AND ORDINANCES

Mechanical engineering design will be in accordance with applicable laws and regulations of the State of California and the Federal Government and applicable local codes and ordinances. Except where noted otherwise, the latest issue of codes and standards, including addenda, in effect at the start of the project will be used. When no other codes or standards govern, the latest revision of the Uniform Building Code (UBC) and the applicable sections of California Building Code (CBC) at the start of the project will govern. The sections in UBC have been quoted throughout this document as reference. These sections are based on the 1997 edition of UBC. However, the latest edition of UBC and the applicable sections of CBC at the start of the project will apply to the engineering design. Pertinent parts of the following documents that are applicable to power plant mechanical engineering design criteria are summarized in this appendix:

- Code of Federal Regulations (CFR)

CFR Title 29	Occupational Safety and Health Administration (OSHA)
40 CFR, Part 60	Standards of Performance for New Stationary Sources, specifically Subpart GG, New Source Performance, Standards (NSPS) for Gas Turbines
40 CFR, Subchapter C	Air Programs, 50 et seq.
40 CFR, Subchapter D	Water Programs, 100 et seq.
40 CFR, Subchapter I	Solid Waste, 260 et seq., Hazardous Waste
40 CFR Subchapter N	Effluent Guidelines & Standards, 400 et seq.

- California Code of Regulations (CCR)

8 CCR	Industrial Safety, General Construction Safety Orders, Industrial Safety Orders, and Work Safety Requirements and Procedures
14 CCR	Natural Resources
17 CCR	Public Health
19 CCR	Public Safety
20 CCR	Public Utilities & Energy
22 CCR	Social Security, Minimum Standards for Management of Hazardous & Extremely Hazardous Waste
23 CCR	Waters
24 CCR	California Building Code; prescribes the use of UBC, UMC, and UPC and provides special building regulations (Part 6)
26 CCR	Toxics

- California Administrative Code, Title 8

Chapters 4 through 7	Groups 20 Flammable Liquids, Gases, and Vapors
Chapter 27	Fire Protection

- California Business and Professional Code

Section 6704	Requires state registration to practice engineering.
Section 6735	Requires that all plans, specifications, reports, or documents prepared by a registered engineer, or by a subordinate under his/her direction, be signed by the registered engineer to indicate responsibility for them.

- California Building Code (CBC)
- Uniform Building Code (UBC)

- Uniform Fire Code (UFC)
- Uniform Mechanical Code (UMC)
- Uniform Plumbing Code (UPC)

C.3 MECHANICAL EQUIPMENT AND COMPONENTS

C.3.1 Codes and Standards

The primary codes, standards, and specifications of the following organizations will be used to establish quality and safety in plant design and operation. Except for some sample specifications, only the sponsoring organization is noted because listing all applicable documents is beyond the scope of this appendix. These codes and standards, referenced in equipment design, specification, and procurement/contract documents, include the latest edition and addenda.

- Air Moving and Conditioning Association (AMCA)

  Publication 201 Fans and Systems

  Publication 203 Field Performance Measurements

  Standard 2402 Drive Arrangements for Centrifugal Fans

- American Boiler Manufacturers Association (ABMA)

  Standards for Steam Quality

- American Gas Association (AGA)
- American Gear Manufacturers Association (AGMA)
- American Iron and Steel Institute (AISI)
- American National Standards Institute (ANSI)

  Various standards for piping and pipe fittings, valves, etc.

  ANSI B133.7M Gas Turbine Fuels

  ANSI B133.8 Gas Turbine Installation Sound Emissions

- American Petroleum Institute (API)

API 616	Gas Turbines for Refinery Services

- American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
- American Society of Mechanical Engineers (ASME)

ASME Section I	Rules for Construction of Power Boilers
ASME Section II	Material Specifications
ASME Section V	Nondestructive Examination
ASME Section VIII	Rules for Construction of Pressure Vessels
ASME Section IX	Welding and Brazing Qualifications
ASME B31.1	Power Piping
ASME B31.8	Gas Transmission and Distribution Piping Systems
ASME PTC 6.1	Interim Test Code for an Alternative Procedure for Testing Steam Turbines
ASME PTC-22	Gas Turbine Power Plants
ASME PTC-23	Atmospheric Water-Cooling Equipment
Standard No. 1	Recommended Practices for the Prevention of Water Damage to Steam Turbines Used for Electric Power Generation, Part I, Fossil Fuel Plants

- American Society for Nondestructive Testing (ASNT)
- American Society of Sanitary Engineers (ASSE)
- American Society of Civil Engineers (ASCE)
- American Society for Testing and Materials (ASTM)
- American Welding Society (AWS)

D1.1	Structural Welding Code

- American Water Works Association (AWWA)

  Standard for Welded Steel Tanks for Water Storage

- Compressed Gas Association (CGA)

  CGA G-2.1 Safety Requirements for the Storage and Handling of Anhydrous Ammonia

- Cooling Tower Institute (CTI) Standard Specification

  Standard Specification for the Design of Cooling Towers

- Ductile Iron Pipe Research Association

- Expansion Joint Manufacturers Association (EJMA)

- Factory Mutual Engineering Corporation (FM)

  Loss prevention data

- Fluid Controls Institute (FCI)

- Heat Exchange Institute (HEI)

- Hydraulic Institute (HI)

- Illuminating Engineering Society (IES)

- Institute of Electrical and Electronics Engineers (IEEE)

- Instrument Society of America (ISA)

- U.S. Department of Defense - Military Specification (MIL Spec)

- Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)

- National Electrical Manufacturers Association (NEMA)

- National Fire Protection Association (NFPA)

  National Fire Codes:

10	Portable Fire Extinguishers
13	Installation of Sprinkler Systems
14	Installation of Standpipe Systems
15	Water Spray Fixed Systems
20	Installation of Centrifugal Fire Pumps
22	Water Tanks for Private Fire Protection
24	Installation of Private Fire Service Mains and Their Appurtenances
30	Flammable and Combustible Liquids Code
70	National Electric Code
72	National Fire Alarm Code
214	Water Cooling Towers
231	Standard for General Storage
255	Surface Burning Characteristics of Building Materials

- Pipe Fabrication Institute (PFI)
- Plastics Pipe Institute (PPI)
- Sheet Metal and Air Conditioning Contractors National Association (SMACNA)
- Steel Structures Painting Council (SSPC)
- Thermal Insulation Manufacturers Association (TIMA)
- Tubular Exchanger Manufacturers Association (TEMA)
- Underwriters' Laboratories Inc. (UL)

C.3.2 Materials - General

Asbestos will not be used in the materials and equipment supplied for the facility. Where feasible, materials will be selected to withstand the design operating conditions, including

expected ambient conditions, for the design life of the plant. It is anticipated that some materials will require replacement during the life of the plant due to corrosion, erosion, etc.

C.3.3 Process Pumps

Vertical shaft pumps will generally be arranged to work with the pump casing submerged in a sump or tank. The suction branch will be arranged vertically downward and, if required for the service conditions, will be fitted with a strainer. The pump shafts will be supported by more than one bearing on each side of the flexible coupling. The discharge piping and nonreturn valve will be arranged to facilitate withdrawing the complete shaft and pump casing as a unit by splitting a pipe joint above floor level.

Strainers (startup or permanent) will be installed in the suction piping of horizontal pumps or sets of pumps. Horizontal-shaft centrifugal pumps will have fully balanced impellers. The driver will be mounted on an extension of the pump bedplate and will drive the pump through a flexible coupling with OSHA coupling guard.

Pumps will operate satisfactorily when delivering varying quantities of fluid up to the maximum pump output. Pump motors will be sized so that the selected pump impeller will not overload the motor at any point on the pump head-capacity curve.

Pumps will be sized in accordance with good engineering practice. Where feasible, pumps will be selected for high efficiency at the normal operating point. Pumps will be free from excessive vibration throughout the operating range.

Where necessary, pumping systems with variable flow requirement will have a recirculation line for pump protection. The recirculation line will normally be routed to the source from which the system takes suction. Modulating or two-position automatic recirculation valves or restriction orifices will be used as applicable. For boiler feedwater pump and condensate pump, modulating automatic recirculation control valves or combined recirculation/check valves will be used.

For each application, pumps will be sized to accept an impeller at least 1/8 inch larger in diameter than the impeller specified without having to change the casing.

Where necessary, vent and drain valves will be fitted at suitable points on the pump casing. Horizontal split case pumps will allow the removable half-casing and impeller to be withdrawn without disturbing any of the process piping or valves. Horizontal end-suction pumps will allow the impeller to be withdrawn from the motor end without disturbing the motor or discharge piping.

Pumps may have either packing or mechanical seals, as determined by the application. Pumps that have mechanical seals will be arranged to facilitate seal removal. Pump design will be specified to prevent packing gland leakage water from entering the bearing housings.

Bearings will have ample surface area and, for large journal pumps, will be split for easy maintenance and arranged to facilitate removal of the pump impeller for repairs.

The inner faces of ball or roller bearings will be fitted directly onto the shaft and located by a machined shoulder on the shaft. For vertically suspended pumps, intermediate shaft bearings will be securely connected to the main pump support tube.

Bearings requiring cooling water will include the appropriate pipework, valves, and strainers. For vertical shaft fresh water or condensate pumps, bearings below water level will be water lubricated.

The weight of the impeller and shafting for vertically suspended pumps will be supported by a thrust bearing, and ample access will be provided for examination and maintenance. Provisions will be made at each end of the bearing to prevent oil or grease from being thrown outside the bearing housing or creeping along the shaft.

Couplings and intermediate shafting will be guarded. Bedplates will be of ample proportions and stiffness to withstand the loads likely to be experienced in shipment and service.

C.3.4 Tanks

Field-erected water storage tanks will be designed, fabricated, erected, inspected, tested, and certified in accordance with ANSI/AWWA D100. The demineralized water storage tank will be constructed of carbon steel with an internal coating. The fire/service water storage tank will be designed in accordance with NFPA 22.

Large outdoor storage tanks will be uninsulated. Drains will be provided as required to prevent damage to the tank wall during extended outages in subfreezing weather.
Overflow connections and lines will be provided. Maintenance drain connections will be provided for complete tank drainage.

Manholes, where included, will be at least 18 inches in diameter and hinged to facilitate removal. Storage tanks will have ladders and cleanout doors as required to facilitate access/maintenance. Provisions will be included for proper tank ventilation during internal maintenance.

C.3.5 Heat Exchangers

The surface condenser will be designed in accordance with HEI standards. Other heat exchangers will be provided as components of mechanical equipment packages and may be shell-and-tube or plate type. Heat exchangers will be designed in accordance with TEMA or manufacturer's standards. Fouling factors will be specified in accordance with TEMA.

As required, heat exchangers will have thermal relief valves.

C.3.6 Pressure Vessels

Pressure vessels will be designed, fabricated, tested, and installed per ASME Code Section VIII and CCR Title 8, Chapter 4.

Pressure vessels will include the following features/appurtenances:

- Process, vent, and drain connections for startup, operation, and maintenance
- Materials compatible with the fluid being handled
- A minimum of one manhole and one air ventilation opening (e.g., handhole) where required for maintenance or cleaning access
- For vessels requiring insulation, shop-installed insulation clips spaced not greater than 18 inches on center
- Relief valves in accordance with the applicable codes

C.3.7 Piping and Piping Supports

Stainless steel pipe may be Schedule 5S or 10S where design pressure permits. Underground piping may be high-density polyethylene (HDPE) where permitted by code, operating conditions, and fluid properties. In general, water system piping will be HDPE where embedded or underground and carbon steel where above ground.

Piping systems containing steam will be of welded construction. Where flanges are required to connect to specific components, they will be raised face types, except for connections to cast iron components. Connections to cast iron components will use flat face flanges. Threaded joints will not be used in piping used for steam, fuel oil, lube oil, and CTG natural gas service. Natural gas piping components will not use synthetic lubricants. Where feasible, victaulic, or equal, couplings will be used for low energy aboveground piping.

Piping systems will have high point vents and low point drains. Drains with restricting orifices or steam traps with startup and blowdown drains and strainers/crud traps will be installed in low points of steam lines where condensate can collect during normal operation.

Steam piping systems in the plant will be sloped in the direction of steam flow, where feasible, with a minimum slope of 1/8-inch per foot. Condensate collection in piping systems will be avoided by installing automatic drain devices and manual devices as appropriate. Steam drain lines in the plant will be sloped at 1/4-inch per foot. The contractor will be allowed to alter this general design requirement if it becomes impractical to maintain strict adherence; however, the piping will still be designed to drain properly.

Steam lines that are fitted with restricting devices, such as orifices in the process runs, will be provided with adequate drainage upstream of the device to ensure that water does not collect in lines.

Means will be provided to fill and clean loop seals.

Hose and process tubing connections to portable components and systems will be compatible with the respective equipment supplier's standard connections for each service.

Large-bore, shop-fabricated metal pipes requiring weld heat treatment during fabrication (except for onsite welding) will be completely immersed in a pickling solution after fabrication to remove grit and mill scale. After immersion, the pipes will be washed in clean water until the solution has been removed.

Piping, pipe supports, and pipe accessories will be designed to resist project-specific loads, CBC-specified loads, 1997 UBC-specified loads, and loads from applicable codes and standards and to be in accordance with the criteria established in this appendix. Typical loadings for a piping system include:

- Dead loads
- Live loads
- Wind loads
- Seismic loads
- Temperature and pressure loads
- Test loads.

Wind loads will be determined using the velocity pressures specified in Appendix B.

The seismic loading and design of piping systems and pipe supports will be in accordance with project-specific criteria. Seismic analysis of piping and components will be in accordance with Section 1630 of the 1997 UBC, and the applicable sections of the CBC.

Hangers and accessories use steel anchor bolts, fasteners, welds, and other pipe anchorage devices. All such pipe anchorages will be designed to resist induced forces. Structural supports required for piping will be designed using static analysis techniques. For all load combinations, including seismic, the stresses in the structural supporting members will remain in the elastic range. Structural allowable strengths will be as indicated for steel structures in Appendix B.

C.3.8 Valves

C.3.8.1 General Requirements

Valves will be arranged for convenient operation from floor level, where possible, and will have extension spindles, chain operators, or gearing, if required. Valve pedestals will be fitted with an indicator to show whether the valve is open or closed.

Hand-actuated valves will be operable by one person. Manual valves 8 inches or larger will have gear operators. Valves will be arranged to close when the handwheel is rotated clockwise when looking at the handwheel from the operating position. The direction of rotation to close the valve will be clearly marked on the face of each handwheel. Valves will be fitted with an indicator to show whether they are open or closed. However, only critical valves will be remotely monitored for position. Valves operating at less than atmospheric pressure will have means to prevent air in-leakage.

Valve materials will be suitable for operation at the maximum working pressure and temperature of the piping to which they are connected. Steel valves will have cast or forged steel spindles. Seats and faces will be of low friction, wear-resistant materials. Valves in throttling service will be selected with design characteristics and of materials that will resist erosion of the valve seats when the valves are operated partly closed.

No provisions will be made for repacking valve glands under pressure. The stops that limit the travel of each valve in the open or closed position will be arranged on the exterior of the valve body.

C.3.8.2 Drain and Vent Valves and Traps

Drains and vents in 900-pound class or higher piping and 500 F or higher service will be double-valved.

Drain traps will have air cock and easing mechanisms. Internal parts will be constructed from corrosion-resistant materials and will be renewable.

Trap bodies and covers will be cast or forged steel and will be suitable for operating at the maximum working pressure and temperature of the piping to which they are connected. Traps will be piped to drain collection tank or sumps and returned to the cycle if convenient.

C.3.8.3 Low Pressure Water Valves

Low-pressure water valves will be the butterfly types of cast iron construction. Cast iron valves will have cast iron bodies, covers, gates (discs), and bridges; the spindles, seats, and faces will be bronze. Fire protection valves will be UL approved and listed for fire protection service in accordance with NFPA requirements.

C.3.8.4 Instrument Air Valves

Instrument air valves will be the ball type of bronze construction, with valve face and seat of approved wear-resistant alloy.

C.3.8.5 Nonreturn Valves

Nonreturn valves for steam service will be in accordance with ANSI standards and properly drained. Nonreturn valves in vertical positions will have bypass and drain valves. Bodies will have removable access covers to enable the internal parts to be examined or renewed without removing the valve from the pipeline.

C.3.8.6 Motor-Actuated Valves

The use of valve motor actuators will be determined based on each valve's functional requirements, accessibility, size, operating environment, and frequency of operation.

Motor-actuated valves will be fitted with both hand and motor operating gear. Motor actuators will have torque switches to stop the motor automatically when the valve gate has reached the "full open" or "full closed" position. The motor actuator will be placed in a position relative to the valve that prevents leakage of liquid, steam, or corrosive gas from valve joints onto the motor or control equipment.

The hand and motor actuation mechanisms will be interlocked so that the hand mechanism is disconnected before the motor is started. Motor actuators will have seating control consisting of a slipping clutch or other torque-limiting device that limits seating force to an acceptable level.

C.3.8.7 Safety and Relief Valves

Pressure vessels, heaters, and boilers will have safety valves and/or relief valves as required by code. Safety and relief valves will be installed vertically. Piping systems that can be over-pressurized by a higher-pressure source will also be protected by pressure relief valves. Equipment or parts of equipment that can be overpressurized by thermal expansion of the contained liquid will have thermal relief valves. Safety valves will be flanged. Silencers will be provided, as required to meet local noise ordinances, for the facility base design.

C.3.8.8 Instrument Root Valves

Instrument root valves will be specified for operation at the working pressure and temperature of the piping to which they are connected. Instrument taps in 900-pound class or higher and 500°F or higher service will be double-valved.

C.3.9 Thermal Insulation and Cladding

Parts of the facility will be thermally insulated to reduce heat loss or afford personnel safety. Insulation surfaces will be designed to limit heat loss to approximately 80 Btu per hour per square foot at 80 F ambient and 2-foot-per-second air velocity. Emissivity is based on aluminum jacketing. The insulation criteria for personnel protection will be such that the temperature on the outside of the lagging does not exceed 140 F when the ambient temperature is approximately 80 F and the air velocity is 30 feet per second.

Thermal insulation will have as its main constituent calcium silicate, foam glass, glass fiber, or mineral wool, and will consist of preformed slabs or blankets, where feasible. Asbestos materials will be prohibited. An aluminum jacket or suitable coating will be provided on the outside surface of the insulation. Where a hard-setting compound is used, it will be nonabsorbent and noncracking. Thermal insulation will be chemically inert even when saturated with water. Insulation system materials, including jacketing, will have a flame spread rating of 25 or less when tested in accordance with ASTM E 84.

Insulation at valves, pipe joints, steam traps, or other points to which access may be required for maintenance will be removable with a minimum of disturbance to the pipe insulation. At each flanged joint, the molded material will terminate on the pipe at a distance from the flange equal to the overall length of the flange bolts to permit their removal without damaging the molded insulation. Steam trap stations will be “boxed” for ease of trap maintenance and freeze protection.

Above ground, insulation piping will be clad with pebbled or corrugated aluminum of not less than 1/32-inch thickness and frame reinforced. At the joints, the sheets will be sufficiently overlapped and corrugated to prevent moisture from penetrating the insulation.

Design temperature limits for thermal insulation will be based on system operating temperature during normal operation.

Outdoor and underground insulation will be moisture-resistant.

Since the facility is designed as a base loaded unit, any piping which is not subject to freezing during plant operation will not be heat traced and/or insulated for freeze protection during shutdown, unless the pipe cannot be readily drained.

C.3.10 Heating, Ventilating, and Air-Conditioning

Heating, ventilating, and air-conditioning (HVAC) systems will be designed and installed in accordance with the California Building Code, Uniform Building Code; Uniform Mechanical Code; American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Standards; Sheet Metal and Air-Conditioning Contractors National Association (SMACNA) Standards; NFPA 90A and NFPA 101; CCR Title 8, Chapter 4; CCR Title 24; ANSI B31.5, Refrigeration Piping Code; and the latest edition of the American Conference of Government Industrial Hygienists, Committee on Industrial Ventilation.

Design conditions for normally occupied areas such as the control room, offices, and toilet rooms are as follows:

- Summer - 78° F dry bulb, 55 percent relative humidity
- Winter -70° F dry bulb.

Because HVAC systems bring filtered outside air into control rooms and offices, the interior pressure is greater than atmospheric pressure. Any air that moves through the openings around doors or windows or elsewhere moves from the higher pressure (inside) to the lower pressure (outside). HVAC system filter efficiency is expected to be approximately 80 percent, thereby controlling dust contamination in these areas.

Except for the HVAC systems serving the control room and administration areas, the systems will not be designed to provide comfort levels for extended human occupancy. The temperature of indoor facilities that are not air-conditioned will be maintained at ambient plus 10° F in summer and a minimum of 55º F in winter.

Air conditioning will include both heating and cooling of the filtered inlet air. Air velocities in ducts and from louvers and grills will be low enough not to cause unacceptable noise levels in areas where personnel are normally located.

Fans and motors will be mounted on anti-vibration bases to isolate them from the building structure. Exposed fan outlets and inlets will be fitted with guards. Wire guards will be specified for belt-driven fans and arranged to enclose the pulleys and belts.

Air filters will be housed in a way that facilitates removal. Filter frames will pass the air being handled through the filter without leakage.

Ductwork, filter frames, and fan casings will be constructed of mild steel sheets stiffened with mild steel flanges and galvanized. Ductwork will be the sectional bolted design and adequately supported. Duct joints will be leaktight.

Grills and louvers will be of adjustable metal construction.

C.3.11 Testing

Hydrostatic testing, including pressure testing at 1.5 times the design pressure, will be specified and performed for pressure boundary components where an in-service test is not feasible or permitted by code.

C.3.12 Welding

Welders and welding procedures will be certified in accordance with applicable codes and standards before performing any welding.

The contractor will be required to maintain indexed records of welder qualifications and weld procedures.

C.3.13 Painting

Except as otherwise specified, equipment will receive the respective manufacturer's standard shop finish. Finish colors will be selected from among the paint manufacturer's standard colors. Finish painting of uninsulated piping and equipment will otherwise be limited to that required by OSHA for safety or for protection from the elements.

Piping to be insulated will not be painted.

C.3.14 Lubrication

The types of lubrication will be suited to plant operating conditions and will comply with the recommendations of the equipment manufacturers.

The initial charge of flushing oil for startup will be provided by the equipment manufacturer and will be the manufacturer's standard lubricant for the intended service. Subsequently, such flushing oil will be sampled and analyzed to determine whether it can also be used for normal operation or it will be replaced in accordance with the equipment supplier's recommendations.

Rotating equipment will be splash lubricated, force lubricated, or self-lubricated. Oil cups will be provided as necessary. Where automatic lubricators are fitted to equipment, provision for emergency hand lubrication will also be specified. Where applicable, equipment will be designed for manual lubrication while the equipment is in operation, without the removal of protective guards. Lubrication filling and drain points will be readily accessible.